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REPORT OF NICHOLAS BAMBOS, PH.D. REGARDING U.S. PATENT NOS. 8,761,130 AND 8,619,726

Huawei Techs Co., Ltd. v. Samsung Elecs. Co., Ltd.,

Case No. 3:16-cv-02787-WHO (N.D. Cal.)

April 27, 2018

5.2.2.8 Channel interleaver

The channel interleaver described in this subclause in conjunction with the resource element mapping for PUSCH in [2] implements a time-first mapping of modulation symbols onto the transmit waveform while ensuring that the HARQ-ACK information is present on both slots in the subframe and is mapped to resources around the uplink demodulation reference signals.

The input to the channel interleaver are denoted by $\underline{g}_0, \underline{g}_1, \underline{g}_2, \ldots, \underline{g}_{H'-1}$, $\underline{q}_0^{RI}, \underline{q}_1^{RI}, \underline{q}_2^{RI}, \ldots, \underline{q}_{Q'_{RI}-1}^{RI}$ and $\underline{q}_0^{ACK}, \underline{q}_1^{ACK}, \underline{q}_2^{ACK}, \ldots, \underline{q}_{Q'_{ACK}-1}^{ACK}$. The number of modulation symbols in the subframe is given by $H'' = H' + Q'_{RI}$.. The output bit sequence from the channel interleaver is derived as follows:

(4) Write the input vector sequence, i.e., $\underline{y}_k = \underline{g}_k$ for $k = 0, 1, \ldots, H'-1$, into the $(R_{mux} \times C_{mux})$ matrix by sets of Q_m rows starting with the vector $\underline{y}_0$ in column 0 and rows 0 to $(Q_m - 1)$ and skipping the matrix entries that are already occupied:

$$\begin{bmatrix} \underline{y}_0 & \underline{y}_1 & \underline{y}_2 & \cdots & \underline{y}_{C_{mux}-1} \\ \underline{y}_{C_{mux}} & \underline{y}_{C_{mux}+1} & \underline{y}_{C_{mux}+2} & \cdots & \underline{y}_{2C_{mux}-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \underline{y}_{(R'_{mux}-1)\times C_{mux}} & \underline{y}_{(R'_{mux}-1)\times C_{mux}+1} & \underline{y}_{(R'_{mux}-1)\times C_{mux}+2} & \cdots & \underline{y}_{(R'_{mux}\times C_{mux}-1)} \end{bmatrix}$$

Exhibit H at 32-33 (SAMSUNG-HNDCA-000009467-68).

555. The mapping of the data multiplexed with CQI into each of the symbols except for the symbols containing the DM RS is performed in a series of steps. The first step is the multiplexing of data and CQI together:

5.2.2.7 Data and control multiplexing

The control and data multiplexing is performed such that HARQ-ACK information is present on both slots and is mapped to resources around the demodulation reference signals. In addition, the multiplexing ensures that control and data information are mapped to different modulation symbols.

The inputs to the data and control multiplexing are the coded bits of the control information denoted by $q_0, q_1, q_2, q_3, \ldots, q_{Q_{CQI}-1}$ and the coded bits of the UL-SCH denoted by $f_0, f_1, f_2, f_3, \ldots, f_{G-1}$. The output of the data and control multiplexing operation is denoted by $\underline{g}_0, \underline{g}_1, \underline{g}_2, \underline{g}_3, \ldots, \underline{g}_{H'-1}$, where $H = (G + Q_{CQI})$ and $H' = H / Q_m$,

Exhibit H at 31 (SAMSUNG-HNDCA-000009466). The coded CQI bits are accordingly denoted by q_i, $i=0,1,2, \ldots Q_{CQI}-1$, while the coded data bits are denoted by f_i, $i=0,1,2, \ldots G-1$. The multiplexed coded data and coded CQI bits, after they go through the "multiplexing operation" are denoted by g_i, $i=0,1,2, \ldots H'-1$, where each g_i is a column of Q_m bits. Subsection

5.2.2.7 accordingly defines the variable H as the sum of G and Q_{CQI}, and the variable H' as being equal to H divided by Q_m. Q_m in this case corresponds to the number of bits per modulation symbol, depending on the type of modulation used. For example, if QPSK modulation is used, then there are 2 bits per modulation symbol, and Q_m is equal to 2. If 64QAM modulation is used, on the other hand, there are 6 bits per modulation symbol, and Q_m is equal to 6. H' thus stands for the number of modulation symbols necessary for coded CQI and data transmission, as it is the quotient of the number of combined data and CQI bits (H) and the number of bits per symbol (Q_m). Subsection 5.2.2.7 confirms this below:

> and where $\underline{g}_i$, $i = 0,...,H'-1$ are column vectors of length Q_m. *H* is the total number of coded bits allocated for UL-SCH data and CQI/PMI information.

Exhibit H at 32 (SAMSUNG-HNDCA-000009467).

556. In the multiplexing process, the CQI bits are placed first in some number of vectors g_i. After the CQI bits are inserted into vectors g_i, then the data bits are added to subsequent vectors g_i:

> The control information and the data shall be multiplexed as follows:
>
> Set i, j, k to 0
>
> while $j < Q_{CQI}$ -- first place the control information
>
> $\underline{g}_k = [q_j \dots q_{j+Q_m-1}]^T$
>
> $j = j + Q_m$
>
> $k = k + 1$
>
> end while
>
> while $i < G$ -- then place the data
>
> $\underline{g}_k = [f_i \dots f_{i+Q_m-1}]^T$
>
> $i = i + Q_m$
>
> $k = k + 1$
>
> end while

Id.

557. After the completion of multiplexing of data and CQI bits, the channel interleaver generates the output signal consisting of data, CQI, and ACK/NAK bits "while ensuring that the HARQ-ACK information is present on both slots of the subframe and is mapped to resources around the uplink demodulation reference signals." *Id.*

558. The channel interleaver consists of a matrix, with input information placed in the matrix row by row, and output information read column by column. The number of columns of the matrix are defined below:

> (1) Assign $C_{mux} = N_{\text{symb}}^{\text{PUSCH}}$ to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2,…, $C_{mux}-1$ from left to right. $N_{\text{symb}}^{\text{PUSCH}}$ is determined according to section 5.2.2.6.

> symbols in the current PUSCH transmission sub-frame given by $N_{\text{symb}}^{\text{PUSCH}} = \left(2 \cdot \left(N_{\text{symb}}^{\text{UL}} - 1\right) - N_{SRS}\right)$, where N_{SRS} is equal to 1 if UE is configured to send PUSCH and SRS in the same subframe for the current subframe or if the PUSCH resource allocation for the current subframe even partially overlaps with the cell specific SRS subframe and bandwidth configuration defined in Section 5.5.3 of [2]. Otherwise N_{SRS} is equal to 0.

Exhibit H at 27, 32 (SAMSUNG-HNDCA-000009462, 9467). Variable N_{SRS} corresponds to the number of SRS symbols in a particular subframe, which equals to 1 if this subframe is scheduled for the SRS transmission or 0 otherwise. Section 8.2 of TS 36.213 v.8.7.0 shows in Table 8.2.1-1 (on pages 56-57) the periodicity of SRS for the FDD mode of LTE. Exhibit XX at 56-57. As shown in this table, the periodicity of SRS can be as much as 320 ms (*i.e.,* 320 subframes), in which case, 319 consecutive subframes have no SRS, and then a frame follows with scheduled transmission of SRS. As such a majority (if not overwhelming majority) of the subframes have no SRS in them and N_{SRS} =0.

559. C_{mux} is accordingly equal to the number of symbols in the subframe minus the number of symbols containing the DM RS.

560. The second step is determining the number of rows in the matrix:

> (2) The number of rows of the matrix is $R_{mux} = (H'' \cdot Q_m)/C_{mux}$ and we define $R'_{mux} = R_{mux} / Q_m$.
>
> The rows of the rectangular matrix are numbered 0, 1, 2,…, $R_{mux} - 1$ from top to bottom.

Exhibit H at 32 (SAMSUNG-HNDCA-000009467). TS 36.213 in Section 7.2.1 (on page 36) explains that a UE transmits RI in PUSCH when it is requested via "a DCI format 0, or a Random Access Response Grant." Exhibit XX at 36. Based on this, PUSCH transmitted in a subframe may not have RI, and for this subframe, H'' is equal to H'. Thus, R_{mux} converts symbols back to bits, by multiplying H'' and Q_m, before subsequently dividing those bits by the number of columns in a subframe, *i.e.*, C_{mux}.

561. R'_{mux} corresponds to the number of subcarriers used for transmission of coded CQI and data symbols. The '130 patent notes that "[a]n exemplary embodiment assumes that each [resource block] includes 12 sub-carriers." Exhibit A, column 2: 1-2. Thus, for purposes of illustration, I assume one resource block per time slot is used for PUSCH and set R'_{mux} equal to 12. Furthermore, for the purposes of this example, I assume the normal cyclic prefix case where there are 14 symbol durations in a subframe and two symbol durations of these 14 symbol durations are occupied by the reference signals. As such, C_{mux} is equal to 12.

562. The third step defines the insertion of rank information "[i]f rank information is transmitted in this subframe." Exhibit H at 32 (SAMSUNG-HNDCA-000009467). As I have explained above, not every subframe transmit the rank information (in the form of rank indicator, RI). For purposes of the '130 patent, this step is not relevant to the locations of data, CQI, and ACK/NAK bits; accordingly, my analysis of the interleaving process does not focus on this step.

563. In the fourth step, the matrix is filled with entries, as described below:

> (4) Write the input vector sequence, i.e., $\underline{y}_k = \underline{g}_k$ for $k = 0, 1, \ldots, H'-1$, into the $(R_{mux} \times C_{mux})$ matrix by sets of Q_m rows starting with the vector $\underline{y}_0$ in column 0 and rows 0 to $(Q_m - 1)$ and skipping the matrix entries that are already occupied:
>
> $$\begin{bmatrix} \underline{y}_0 & \underline{y}_1 & \underline{y}_2 & \cdots & \underline{y}_{C_{mux}-1} \\ \underline{y}_{C_{mux}} & \underline{y}_{C_{mux}+1} & \underline{y}_{C_{mux}+2} & \cdots & \underline{y}_{2C_{mux}-1} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \underline{y}_{(R'_{mux}-1)\times C_{mux}} & \underline{y}_{(R'_{mux}-1)\times C_{mux}+1} & \underline{y}_{(R'_{mux}-1)\times C_{mux}+2} & \cdots & \underline{y}_{(R'_{mux}\times C_{mux}-1)} \end{bmatrix}$$

Id. Again, g_k, which is in turn converted to y_k, corresponds to the multiplexed coded data and coded CQI. Assuming that R'_{mux} is equal to 12 and C_{mux} is equal to 12, as I describe above, the first row of the matrix consists of the following entries: $y_0, y_1, y_2, \ldots y_{11}$. The second row of the matrix consists of the following entries: $y_{12}, y_{13}, y_{14}, \ldots y_{23}$. The last row consists of the following entries: $y_{132}, y_{133}, y_{134}, \ldots y_{143}$. As with the multiplexing process, coded CQI information is first mapped into the matrix, followed subsequently by coded data information.

564. As described in Section 5.3.4 of TS 36.211 below, the multiplexed data and CQI information is mapped to every symbol not containing the DM RS. Each symbol, in other words, consists of coded CQI and data information mapped over different subcarriers:

5.3.4 Mapping to physical resources

The block of complex-valued symbols $z(0),...,z(M_{\text{symb}}-1)$ shall be multiplied with the amplitude scaling factor β_{PUSCH} in order to conform to the transmit power P_{PUSCH} specified in Section 5.1.1.1 in [4], and mapped in sequence starting with $z(0)$ to physical resource blocks assigned for transmission of PUSCH. The mapping to resource elements (k,l) corresponding to the physical resource blocks assigned for transmission and not used for transmission of reference signals and not reserved for possible SRS transmission shall be in increasing order of first the index k, then the index l, starting with the first slot in the subframe.

If uplink frequency-hopping is disabled, the set of physical resource blocks to be used for transmission are given by $n_{\text{PRB}} = n_{\text{VRB}}$ where n_{VRB} is obtained from the uplink scheduling grant as described in Section 8.1 in [4].

If uplink frequency-hopping with type 1 PUSCH hopping is enabled, the set of physical resource blocks to be used for transmission are given by Section 8.4.1 in [4].

If uplink frequency-hopping with predefined hopping pattern is enabled, the set of physical resource blocks to be used for transmission in slot n_s is given by the scheduling grant together with a predefined pattern according to

$$\tilde{n}_{\text{PRB}}(n_s) = \left(\tilde{n}_{\text{VRB}} + f_{\text{hop}}(i)\cdot N_{\text{RB}}^{\text{sb}} + \left(\left(N_{\text{RB}}^{\text{sb}}-1\right) - 2\left(\tilde{n}_{\text{VRB}} \bmod N_{\text{RB}}^{\text{sb}}\right)\right)\cdot f_{\text{m}}(i)\right) \bmod \left(N_{\text{RB}}^{\text{sb}}\cdot N_{\text{sb}}\right)$$

$$i = \begin{cases} \lfloor n_s/2 \rfloor & \text{inter – subframe hopping} \\ n_s & \text{intra and inter – subframe hopping} \end{cases}$$

$$n_{\text{PRB}}(n_s) = \begin{cases} \tilde{n}_{\text{PRB}}(n_s) & N_{sb}=1 \\ \tilde{n}_{\text{PRB}}(n_s) + \left\lceil N_{\text{RB}}^{\text{HO}}/2 \right\rceil & N_{sb}>1 \end{cases}$$

$$\tilde{n}_{\text{VRB}} = \begin{cases} n_{\text{VRB}} & N_{sb}=1 \\ n_{\text{VRB}} - \left\lceil N_{\text{RB}}^{\text{HO}}/2 \right\rceil & N_{sb}>1 \end{cases}$$

where n_{VRB} is obtained from the scheduling grant as described in Section 8.1 in [4]. The parameter *pusch-HoppingOffset*, $N_{\text{RB}}^{\text{HO}}$, is provided by higher layers.. The size $N_{\text{RB}}^{\text{sb}}$ of each sub-band is given by,

$$N_{\text{RB}}^{\text{sb}} = \begin{cases} N_{\text{RB}}^{\text{UL}} & N_{\text{sb}}=1 \\ \left\lfloor \left(N_{\text{RB}}^{\text{UL}} - N_{\text{RB}}^{\text{HO}} - N_{\text{RB}}^{\text{HO}} \bmod 2\right)/N_{\text{sb}} \right\rfloor & N_{\text{sb}}>1 \end{cases}$$

where the number of sub-bands N_{sb} is given by higher layers. The function $f_{\text{m}}(i)\in\{0,1\}$ determines whether mirroring is used or not. The parameter *Hopping-mode* provided by higher layers determines if hopping is "inter-subframe" or "intra and inter-subframe".

Exhibit F at 15 (SAMSUNG-HNDCA-000009367).

565. In the final step, ACK/NAK information "overwrites" some of the channel interleaver entries:

(5) If HARQ-ACK information is transmitted in this subframe, the vector sequence $\underline{q}_0^{ACK}, \underline{q}_1^{ACK}, \underline{q}_2^{ACK}, \ldots, \underline{q}_{Q'_{ACK}-1}^{ACK}$ is written onto the columns indicated by Table 5.2.2.8-2, and by sets of Q_m rows starting from the last row and moving upwards according to the following pseudocode. Note that this operation overwrites some of the channel interleaver entries obtained in step (4).

Set i, j to 0.

Set r to $R'_{mux} - 1$

while $i < Q'_{ACK}$

$c_{ACK} = \text{ColumnSet}(j)$

$\underline{y}_{r \times C_{mux} + c_{ACK}} = \underline{q}_i^{ACK}$

$i = i + 1$

$r = R'_{mux} - 1 - \lfloor i/4 \rfloor$

$j = (j + 3) \bmod 4$

end while

Where ColumnSet is given in Table 5.2.2.8-2 and indexed left to right from 0 to 3.

Id. Thus, starting in the last row of the matrix, ACK/NAK information is inserted, moving upwards, according to the code described above. As I demonstrate below, the ColumnSet governing the insertion of ACK/NAK information results in ACK/NAK information being placed in the symbols directly adjacent to the reference signal. In addition to the ColumnSet variable limiting the ACK/NAK information to only certain columns (symbol positions) in the matrix, however, the ACK/NAK information only overwrites some of the data in each row ACK/NAK information is inputted into given the definition of *r* above. As a result, the symbol positions that ACK/NAK information is mapped into also contains data.

566. In sum, the channel interleaver shows that data is mapped to each of the symbols in the subframe that are not used to map the reference signal.

567. It is my understanding that Huawei has mapped v.8.7.0 of subsections 5.2, 5.3, and 5.5 of TS 36.211 and subsection 5.2.2 of TS 36.212 to the asserted claims of the '130 patent

Instrumentalities could communicate with LTE-related base stations. Exhibit L at 22:17-23:10; 27:15-19; 30:4-23; 35:18-36:8.

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Figure 5.3-1: Overview of uplink physical channel processing.

Exhibit F at 13 (SAMSUNG-HNDCA-000009365).

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c. **Documentation and Source Code for the Qualcomm-Based Accused Instrumentalities**

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this limitation under the doctrine of equivalents, as any alleged differences are insubstantial. The Accused Instrumentalities are performing substantially the same function (i.e., PUSCH signal transmission) in substantially the same way (placing ACK/NAK information in the symbols directly adjacent to the DM RS along with data and transmitting the DM RS, ACK/NAK, and data, which is mapped to every symbol except for the symbols containing the DM RS and is multiplexed with CQI) to get substantially the same result (i.e., transmitting a signal with minimal distortion of the underlying information).

4. Claim 13[D]: "mapping the acknowledgement information to first symbols among the remaining symbols in the slot, the first symbols not being used to map reference signals and the first symbols being directly adjacent to the middle symbol"

595. Each of the Accused Instrumentalities map "acknowledgement information to first symbols among the remaining symbols in the slot, the first symbols not being used to map reference signals and the first symbols being directly adjacent to the middle symbol," as recited in claim 13[D].

596. As I have demonstrated, the mapping of acknowledgement information claimed in the '130 patent is a puncturing technique, where ACK/NAK information is inserted into symbols already carrying data, effectively taking the place of bits of data within the symbols. Because ACK/NAK bits are much smaller than data bits, they do not take up the whole symbol. This puncturing technique is highlighted in gray in Figure 2 of the '130 patent below:

687. As seen below, the data and CQI multiplexing step takes place after the code block concatenation process in the processing structure:

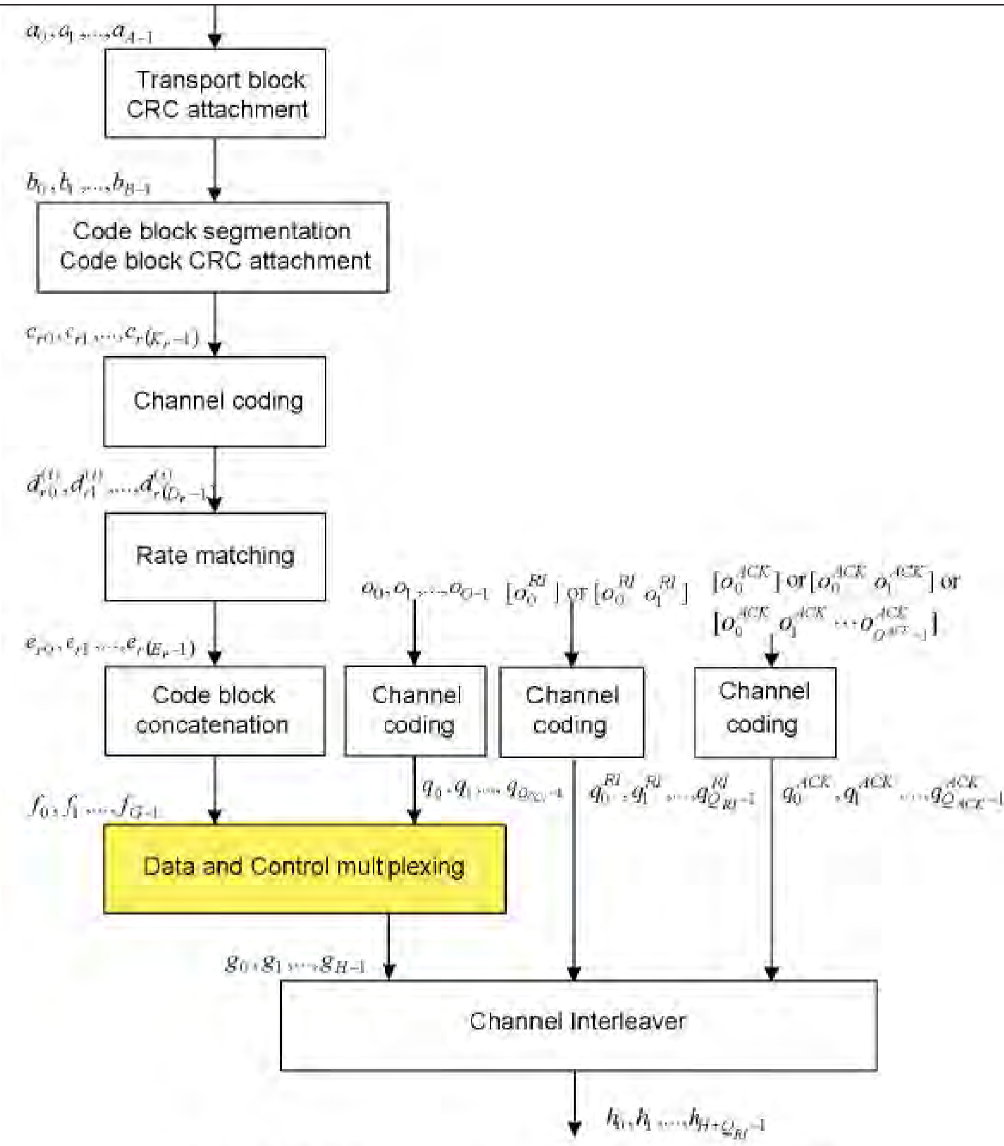

Figure 5.2.2-1: Transport channel processing for UL-SCH

Exhibit H at 21 (SAMSUNG-HNDCA-000009456) (highlighting added). As seen in the diagram, the data bits, *f*, and the CQI bits, *q*, are multiplexed together to produce the resulting output *g*, consisting of the multiplexed data and CQI bits. The multiplexed data and CQI bits are

then inputted into the channel interleaver, along with the ACK/NAK bits after the ACK/NAK bits have undergone channel coding.

688. It is my understanding that Huawei has mapped v.8.7.0 of subsections 5.2, 5.3, and 5.5 of TS 36.211 and subsection 5.2.2 of TS 36.212 to the asserted claims of the '130 patent in its invalidity contentions. *See* Exhibit PPP (Exhibit H-5 to Huawei's Invalidity Contentions). I disagree that either document constitutes prior art because both were published in June 2009, while the '130 patent has a priority date of June 8, 2007, as I have demonstrated above. Accordingly, the versions of the 3GPP standard charted by Huawei do not qualify as prior art and cannot invalidate the asserted claims. Nevertheless, in my opinion, Huawei's invalidity contentions are an admission by Huawei that the asserted claims read on to the standard.

b. Documentation and Source Code for the HiSilicon-Based Accused Instrumentalities

689. [redacted]

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691. [redacted]

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c. <u>Documentation and Source Code for the Qualcomm-Based Accused Instrumentalities</u>

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706. [redacted]

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B. <u>The Accused Instrumentalities Infringe Claim 16 of the '130 Patent</u>

709. Based on my review of the 3GPP specifications and documents, source code and other information from Huawei, HiSilicon, Qualcomm, and other third parties, it is my opinion that each of the Accused Instrumentalities infringe every limitation of Claim 16 of the '130 patent. My conclusion is based upon the sections above and my review of Samsung's infringement contentions for the '130 patent.

710. Claim 16 recites: "the method as in claim 13, wherein the slot consists of 7 symbols, the reference signal is mapped to a 4th symbol among the 7 symbols, and the acknowledgement information is mapped only to 3rd and 5th symbols among the 7 symbols."

5.3.2.2 HARQ process

For each subframe where a transmission takes place for the HARQ process, one or two (in case of spatial multiplexing) TBs and the associated HARQ information are received from the HARQ entity.

For each received TB and associated HARQ information, the HARQ process shall:

- if the NDI, when provided, has been toggled compared to the value of the previous received transmission corresponding to this TB; or
- if the HARQ process is equal to the broadcast process and if this is the first received transmission for the TB according to the system information schedule indicated by RRC; or
- if this is the very first received transmission for this TB (i.e. there is no previous NDI for this TB):
  - consider this transmission to be a new transmission.
- else:
  - consider this transmission to be a retransmission.

Exhibit FF at 17-19 (HW_Samsung_00257366-68).

836. Subsection 5.3 of TS 36.321 specifically states that the HARQ Process ID is calculated based on "the number of HARQ processes," time information, which corresponds to the variable CURRENT_TTI, and persistent resource allocation interval information, which corresponds to the variable Downlink Semi-Persistent Scheduling Interval, *i.e.*, "the periodicity of semi-persistent scheduling scheduled via RRC." Exhibit FF at 18 (HW_Samsung_00257367). In other words, this subsection of TS 36.321 calculates a HARQ process ID based on the variables *i, n*, and *t* defined in equation (2) of the '726 patent. Exhibit DD, col. 8:65.

837. Subsection 5.3 of TS 36.321 additionally states that "[e]ach HARQ process is associated with a HARQ process identifier." Exhibit FF at 19 (HW_Samsung_00257368).

838. It is my understanding that Huawei has mapped v.8.7.0 of subsection 6.3.2 of TS 36.331 and subsections 5.3.1 and5.3.2 of TS 36.321 to the asserted claims of the '726 patent in its invalidity contentions. *See* Exhibit OOO (Exhibit G-10 to Huawei's Invalidity Contentions). I disagree that either document constitutes prior art because both were published in September 2009, while the '726 patent has a priority date of August 7, 2007, as I have demonstrated above. Accordingly, the versions of the 3GPP standard charted by Huawei do not

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(c) **Documentation and Source Code for the Qualcomm-Based Accused Instrumentalities**

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1018. It is my opinion that the Asserted Claims, as found in the Accused Instrumentalities, provide substantial benefits to Huawei's customers.

1019. It is my opinion that secondary considerations support the non-obviousness of the Asserted Claims.

1020. I reserve the right to adjust or supplement my opinion after I have had the opportunity to review other deposition testimony or in light of additional documents or other discovery that may be brought to my attention. I also reserve the right to adjust or supplement my analysis in light of any critiques or comments on my report and to offer additional opinions and evidence in reply to any opinions advanced by or on behalf of Huawei.

1021. I may amend or supplement this report as necessary based on such additional information, or to address any new claim constructions offered by Huawei, Samsung, or provided by the Court.

I certify under penalty of perjury that the foregoing is true and correct.

N Bambos

Nicholas Bambos